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LBP: Local Binary Pattern

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Outline

- Introduction
- Binary Encoding
- Non-Uniform Pattern Handling
- Block Description

Introduction

- Origin of LBP
  - LBP is a particular case of texture spectrum proposed by He and Wang.

    D. C. He and L. Wang, "Texture Unit , Texture Spectrum, and Texture Analysis", *IEEE Trans. on Geoscience and Remote Sensing*, 1990

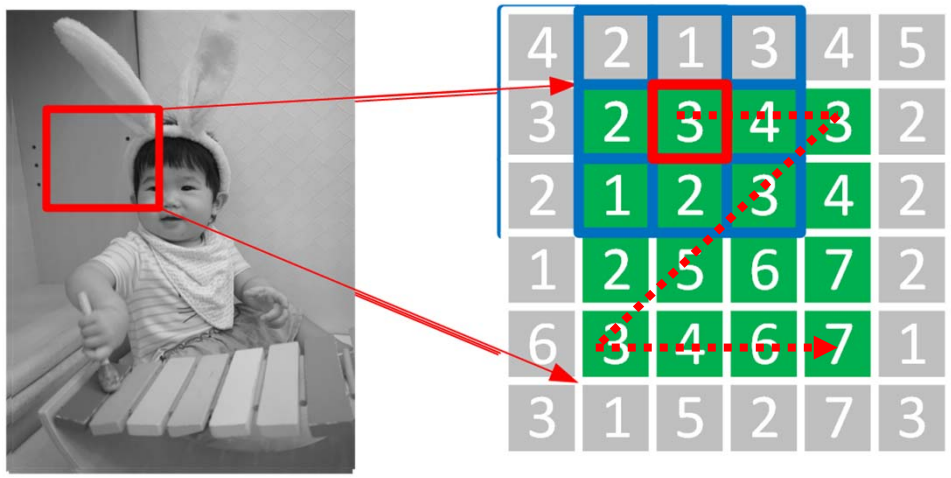
  - The effectiveness of LBP was proven and described by Ojala *et. al.*

    T. Ojala. *et. al.*, "A Comparative Study of Texture Measures with Classification Based on Feature Distributions," *Pattern Recognition*, 1996.

Introduction

- About LBP
  - LBP is a descriptor for describing the texture of a rectangular block.

Step1: encode every point in the block as a pattern called LBP



LBP

58	37	58	27
57	50	50	58
58	30	31	2
58	58	42	16

Introduction

- About LBP
  - LBP is a descriptor for describing the texture of a rectangular block.

Step2: gather statistics of LBP occurrence in histogram form

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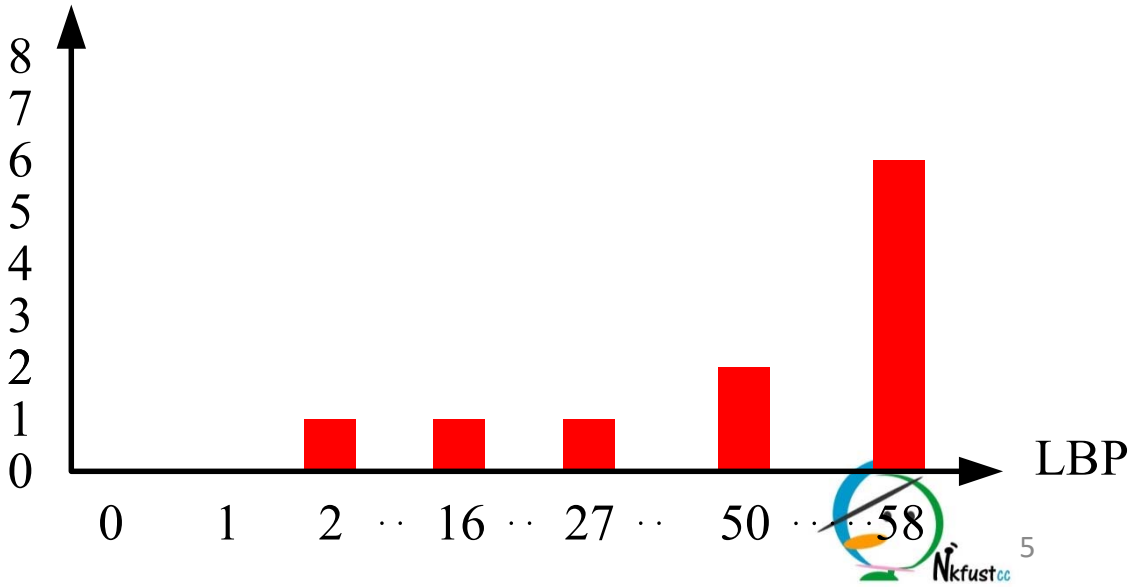
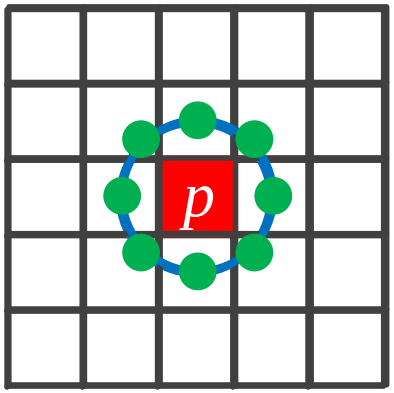
LBP

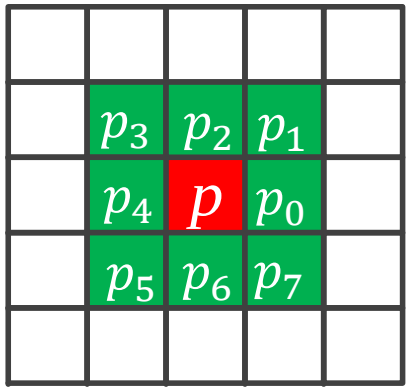


Binary Encoding

- Texture Unit $TU(.)$
  - It is a basic element for LBP encoding
  - It consists of a point p and its 8 neighbors
    - 8 neighbors are on a circle with radius R
    - 8 neighbors are equally sampled on the circle



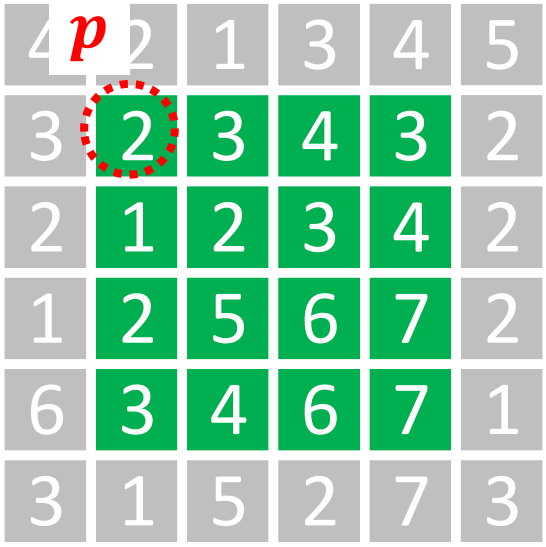
$R = 1$

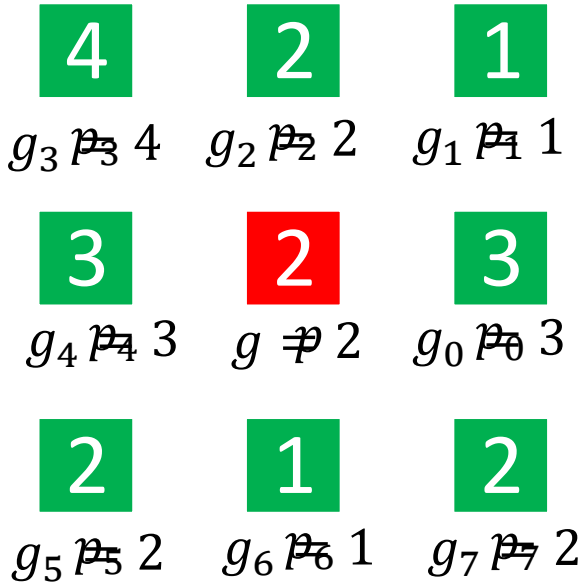


$TU(p) = \{p, p_0, p_1, .. p_7\}$

Binary Encoding

- Binarization
  - Let g be intensity of p; g_i be intensity for p_i





$TU(p)$

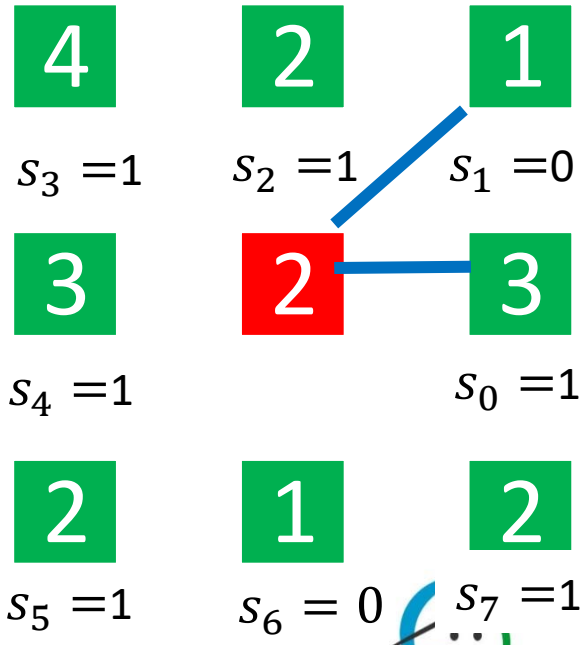
Binary Encoding

- Binarization
  - Threshold g_i by center intensity g to obtain binary values $s_i \in \{0,1\}$

$$s_i = \begin{cases} 1 & if \quad g_i \geq g \\ 0 & \quad\quad g_i < g \end{cases}$$

$$(g_0 = 3) > (g = 2) \Rightarrow s_0 = 1$$

$$(g_1 = 1) < (g = 2) \Rightarrow s_1 = 0$$



Binary Encoding

- 256-Level Encoding
  - interpret the sequence $< s_7, s_6, \ldots s_1, s_0 >$ as a 8-bit unsigned integer (LBP)

4	2	1
$s_3 = 1$	$s_2 = 1$	$s_1 = 0$
3	2	3
$s_4 = 1$	p	$s_0 = 1$
2	1	2
$s_5 = 1$	$s_6 = 0$	$s_7 = 1$

$$LBP(p) =< s_7, s_6, \ldots s_1, s_0 >$$

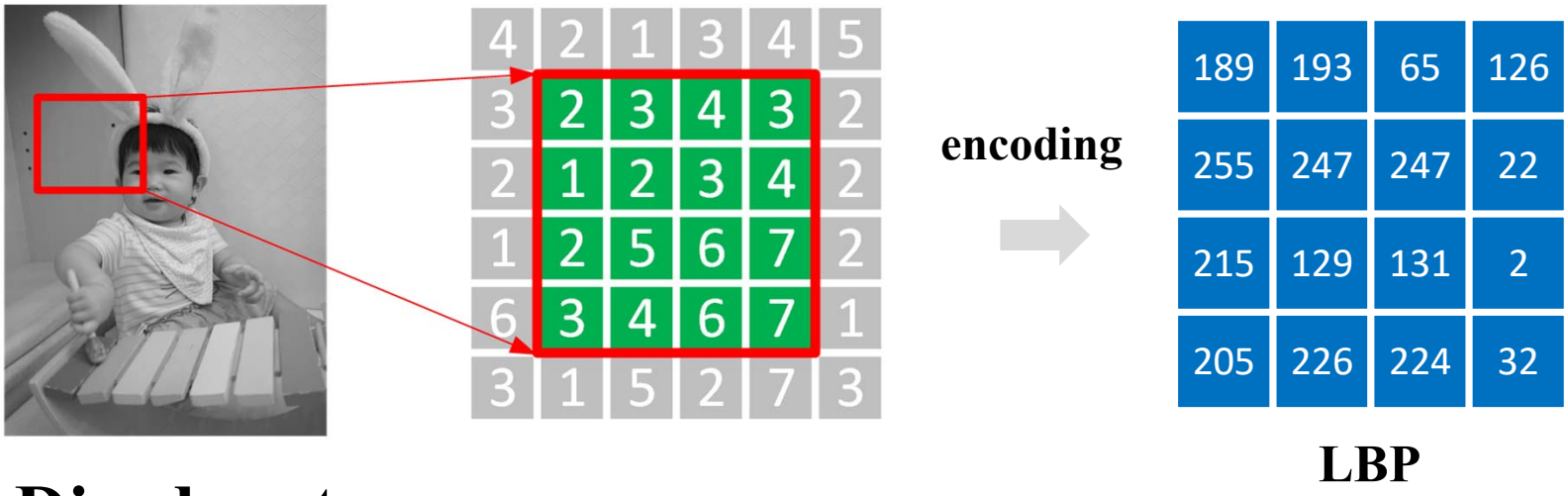
$$=< 1,0,1,1,\ 1,1,0,1 >$$

$$= 1 \times 2^7 + 0 \times 2^6 + \cdots 1 \times 2^0$$

$$= 189$$

Binary Encoding

- 256-Level Encoding



Disadvantage:

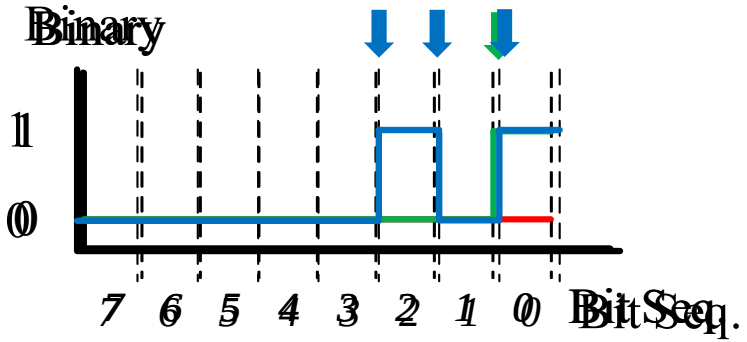
- ineffective in case of noisy regions (i.e. complex background)
- overfitting in case of low-resolution images

M. Heikkilä, M. Pietikäinen, "A Texture-based Method for Modeling the Background and Detecting Moving objects", IEEE Trans. on PAMI, 2006.

Non-Uniform Pattern Handling

- Non-Uniform LBP
  - Non-Uniform LBP generally results from the noisy region.
  - Non-Uniform LBP is a bit sequence with more than 2 bitwise transitions (0→1 or 1→0)

Bit Sequence	# Transition	Uniform?
0000 0000	0	Yes
0000 0001	1	Yes
0000 0101	3	No



Non-Uniform Pattern Handling

- 59-Level Encoding
  - 58 uniform LBP: assign each with an unique index (from 0 to 57)
  - 198 non-uniform LBP: assign all with index 58

LBP	Uniform?	Bin Index
0000 0000	Yes	0
0000 0001	Yes	1
0000 0010	Yes	2
0000 0011	Yes	3
0000 0100	Yes	4
0000 0101	No	58
0000 0110	Yes	5
0000 0111	Yes	6

LBP	Uniform?	Bin Index
0000 1000	Yes	7
0000 1001	No	58
0000 1010	No	58
0000 1011	No	58
0000 1100	Yes	8
0000 1101	No	58
0000 1110	Yes	9
0000 1111	Yes	10

LBP	Uniform?	Bin Index
1111 1000	Yes	51
1111 1001	**Yes**	**52**
1111 1010	No	58
1111 1011	**Yes**	**53**
1111 1100	**Yes**	**54**
1111 1101	**Yes**	**55**
1111 1110	Yes	56
1111 1111	Yes	57

Non-Uniform Pattern Handling

- 59-Level Encoding

189	193	65	126
255	247	247	22
215	129	131	2
205	226	224	32

256-Level LBP

Non-Uniform Handling

58	37	58	27
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58	30	31	2
58	58	42	16

59-Level LBP

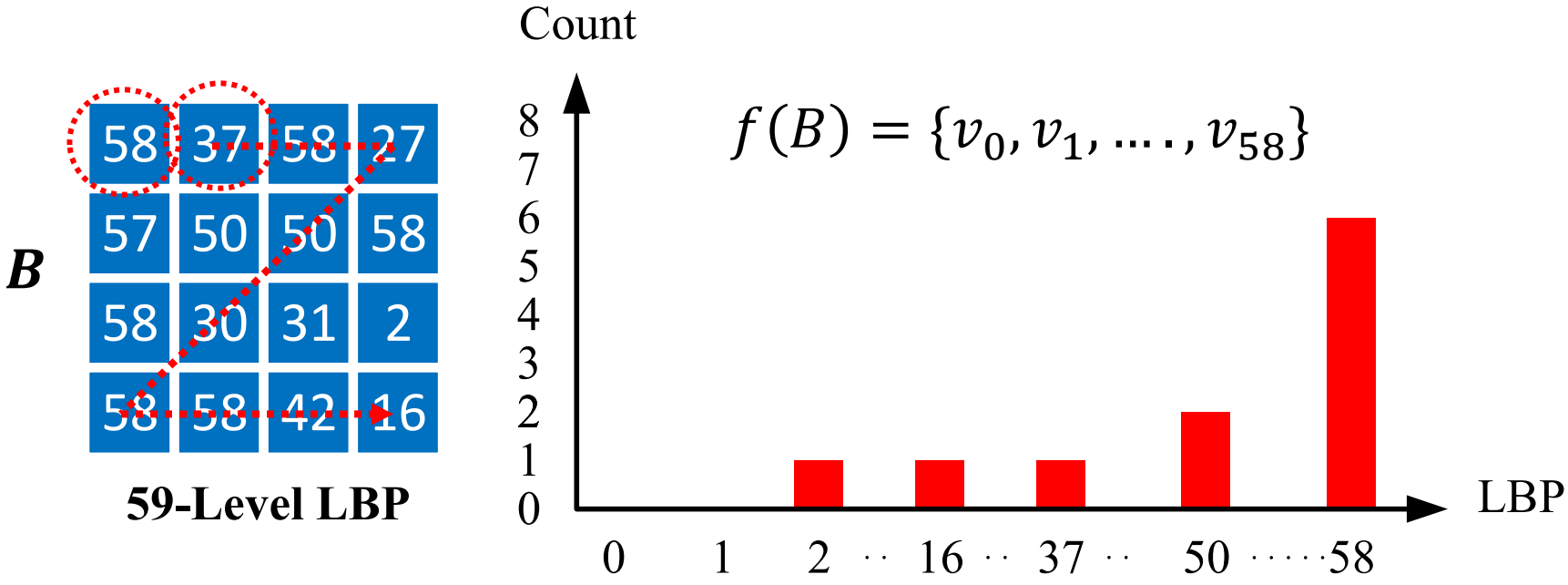
LBP	Uniform?	Bin Index
0	Yes	0
1	Yes	1
2	Yes	2
3	Yes	3
4	Yes	4
5	No	58
6	Yes	5
7	Yes	6

LBP	Uniform?	Bin Index
8	Yes	7
9	No	58
10	No	58
11	No	58
12	Yes	8
13	No	58
14	Yes	9
15	Yes	10

LBP	Uniform?	Bin Index
248	Yes	51
249	Yes	52
250	No	58
251	Yes	53
252	Yes	54
253	Yes	55
254	Yes	56
255	Yes	57

Block Description

- LBP Histogram Formation
  - gather statistics of LBP occurrence in a form of histogram.



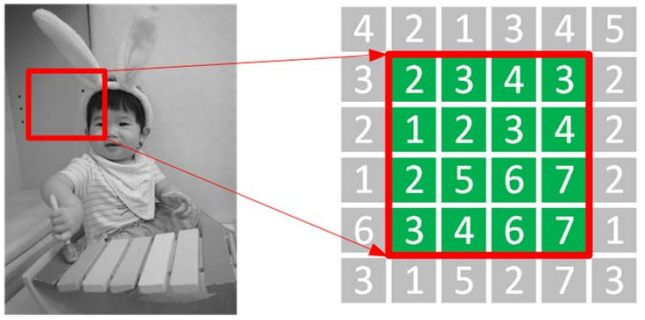
Block Description

- Normalization
  - normalize the block feature vector to unity so as to be invariant to block size

$$f(B) = \frac{1}{Z}\{v_0, v_1, \ldots, v_{3780}\}$$

  - Z: Normalization Term

$$Z = |B|$$



$$Z = |B| = 16$$


thank you
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